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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Tobacco smoke filters.

We, U.S. FILTER CORPORATION, of 8401, Jefferson Davis Highway, Richmond, Virginia, United States of America, a corporation incorporated under the laws of the State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of forming a porous body suitable as a tobacco smoke filter.

According to the present invention a method of forming such a porous body comprises feeding a mixture of sorbent granules and a thermoplastic bonding agent therefor on to a flexible belt, shaping the belt to collect the mixture into a body of the required configuration, heating the shaped mixture to form it into a coherent porous body, and thereafter separating the body from the belt.

The mixture is preferably fed on to a belt of flexible porous material which is thereafter shaped to form a tube so as to collect the mixture into a rod, a hot gas or vapour such as steam being passed through the porous wall of the tube to form the mixture therein to a coherent porous filter rod.

British Specification No. 1,083,353 (Application No. 36153/64) describes and claims a tobacco smoke filter suitable for use in cigarettes comprising a coherent porous body of sorbent granules bonded together with a thermoplastic bonding agent, and a method for producing such a filter comprising forming a mixture of sorbent granules and a thermoplastic bonding agent therefor and shaping and heating the mixture to cause the bonding agent to fuse or soften to bond the sorbent granules into a coherent porous filter body.

In one continuous process according to the invention, for example, a particulate mixture of a granular sorbent material such

as activated carbon and a bonding agent such as a polyolefin is fed at a predetermined rate on to an endless flexible belt of porous material which carries the mixture past a suction station a heat-treatment station, and finally a cooling station. As the belt passes the suction a partial vacuum is applied to its underside, the belt then being shaped to form a tube enclosing the mixture as or before it passes into the heat-treatment device where steam is injected through the porous walls of the belt to heat the mixture and bond it into a coherent porous filter rod. The density, and hence the pressure drop, of the filter rod formed may be simply yet accurately controlled by controlling the rate at which the mixture is fed on to the belt relative to the velocity of the belt, as the injection of steam disperses the mixture to fill the tube to produce a bonded rod corresponding in shape and size to the tube. On leaving the heating device the filter rod enclosed by the porous belt passes to a cooling station where a cold inert gas such as air is injected through the belt to cool the filter rod, the belt thereafter flattening out for return to the feeding station as the finished filter rod is fed to a cutting device to be divided into lengths for further handling.

The initial mixture may comprise granules of sorbent material together with particles of the thermoplastic bonding agent. The particles of bonding agent are preferably spherical or ellipsoidal and substantially smaller than the granules of sorbent material, so that they adhere thereto as a dust-like coating on mixing. A predominant portion, e.g. at least 80%, of the sorbent granules may for example be from 9 to 200, preferably between 9 and 60, times larger than the resin particles. Each sorbent granule in the mixture is thus separated from adjacent sorbent granules by a contiguous layer of thermoplastic powder, which softens or fuses on heating, so that the formation of a firmly bonded yet porous pro-

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duct is ensured. Resin particles of an average diameter of 100 microns or less, preferably 50 microns or less, are particularly suitable, whilst at least 80% of the sorbent granules are preferably of about 100 to 12 or 10 mesh, U.S. Standard, but may be as fine as 200 mesh.

Instead of such a mixture of discrete sorbent granules and bonding agent particles, sorbent granule coated with thermoplastic resin may be employed. For example an aqueous polyethylene emulsion can be mixed with activated carbon granules to form a thermoplastic coating thereon, the coated granules then being formed into the filter structure as described above. By co-blending at least a portion of the resin as an emulsion in a liquid carrier the formation of a homogeneous mixture is greatly facilitated and closer control over product quality is made possible.

The initial mixing of sorbent granules and thermoplastic resin may be carried out in a hammer-mill, in a ribbon blending machine, a V core blender or any machine giving an equivalent mixing action. Such machines give particularly good results when a portion of the resin is added as an emulsion as described above.

The use of steam for softening the thermoplastic component of the mixture is particularly advantageous since it helps to remove deactivating impurities from the sorbent. When the mixture comprises sorbent granules dusted with thermoplastic powder, it may with advantage be subjected to gentle pre-heating so as to initially bond the powder coating more firmly thereby preventing any disruption of the coating which might otherwise occur on the subsequent relatively violent injection of steam.

Activated carbon is the preferred material for use as the granular sorbent, due to its high adsorptive efficiency and comparative cheapness, but other granular materials possessing useful filtration properties, for example silica gel, activated alumina, perlite, sepiolite, soda, Fullers earth, magnesium silicate, asbestos powder, metal oxides such as iron oxide, and combinations thereof, may be employed in addition to or in place of activated carbon. The carbon is preferably of coal base type rather than nutshell or petroleum base, and the carbon and binder are preferably of about the same apparent density, e.g. carbon 0.16 to 0.50 and bonding agent 0.38 to 0.42.

The commercially available polyolefins such as polyethylene and polypropylene and their copolymers are non-toxic and thermally stable, and will set to give a strong bond without clogging the pores of the sorbent granules, which therefore retain their sorbent power in the finished product. These materials are therefore particularly well suited for

use as the bonding agent. Other polyhydrocarbons may be employed in place of or in addition to polyethylene or polypropylene, particularly polymers of hydrocarbons containing 4 to 10 carbon atoms, as may a variety of other thermoplastic materials having suitable melt flow indices, such as vinyl acetate and other vinyl homopolymers and copolymers, plasticised cellulose acetate, polyester resins such as 'Artrite', (Trade Mark) friable polyhydrocarbon resins such as 'Escorez', and combinations thereof. Microporous polyethylene possesses sorptive properties, and may be employed as a sorbent material and/or as a binder. The preferred binders for the steam heating process are polyolefins, particularly polyethylene, having a melt index (ASTM) of 5 or more.

A minor proportion of one or more fillers may be incorporated in the mixture, for example natural or synthetic fibres, puffed and/or comminuted tobacco stocks and stems, alkali and acid modifiers, metal fibres, fibrous carbon, chemicals which affect the taste of smoke passing through the filter, and in particular certain active additives which eliminate some of the harmful constituents from tobacco smoke and hence enhance the efficiency of the filter. Examples of additives include sugars, powdered calcium carbonate and wood pulp. Binders may be employed which have an effect upon the smoke, e.g. plasticised cellulose acetate which removes phenols and aldehydes.

Orzan, a sulphonate polymer, possessing good dispersing and chelating properties, has been found to be a suitable additive for improving hardness and sorptivity. Sucrose (table sugar) and methyl cellulose serve as suitable additives to improve hardness and sorptivity. N-vinyl-5-methyl-2-oxazolidinone (Delvex) is a useful additive because of its film forming and chelating properties, and when used, the resultant filter has improved uniformity as well as good sorptivity and hardness.

The large specific surface of sorbent materials makes them suitable as carriers for additives having a chemical or a flavouring action on the tobacco smoke. Such additives include copper, zinc, iron and other metallic salts and oxides which exert a chemical action on the gas phase of the smoke, and menthol, citral, etc. which may be used to impart a desirable flavour.

Granular tobacco, preferably granulated tobacco stems, may be included in the mixture, improving the taste of cigarette smoke filtered through the filter formed therefrom. It is found that cigarettes provided with a filter formed according to the invention from a mixture including granulated tobacco provide a smoke similar in taste to that of un-tipped cigarettes. The ratio of tobacco granule size to sorbent granule size may for

example be between 2:1 to 0.5:1 and is preferably about 1:1. Particulate fillers other than granulated tobacco preferably have a particle size of 50 microns or less.

- 5 Other materials which may be included in the mixture, and which may serve as bonding agents, are polycarbonates obtained by reacting bisphenol A and diphenyl carbonate, polyamides of the nylon type, e.g. nylon 6, 10 nylon 6/6 and nylon 6/10, modified cellulosic resins, e.g. cellulose acetate, and dimethyl cellulose, and powdered natural gums.

- 15 The filter may comprise 5% by weight or less of bonding agent, or as much as 50% by weight and from 50% to 95% by weight of sorbent granules. Preferably not more than 40% by weight of binder is employed, and not less than 56% or 20 60% by weight of sorbent granules. The most satisfactory filters include at least 64%, but not more than 30% by weight of binder and from 70% to 93½% by weight of non-binder material. At least 80%, e.g. from 25 85-93½% of sorbent granules are preferably employed, unless granular tobacco is employed. Granular tobacco may constitute at least 20%, e.g. from 30% to 60% of the mixture.

- 30 A preferred method according to the invention will now be described by way of example with reference to the accompanying drawings in which:—

- 35 Fig. 1 is a diagrammatic representation showing the disposition of the various parts of the apparatus employed in the method,

Fig. 2 is a sectional view, taken on the line II-II of Fig. 1,

- 40 Fig. 3 is a sectional view, taken on the line III-III of Fig. 1,

Fig. 4 is a longitudinal section view of the steaming device 24 of Fig. 1,

Fig. 5 is a longitudinal sectional view of the cooling device 26 of Fig. 1, and

- 45 Fig. 6 is a graph comparing the filtration efficiency of a filter made according to the invention with that of a conventional filter.

- Referring to Fig. 1 there is shown a hopper 2 from which the mixture of sorbent 50 granules and thermoplastic resin, with or without filler material and/or additives, is fed on to an endless, porous, flexible belt 6 and carried thereon through a suction station 22, a steam treatment station 24 and a cooling 55 station 26, whereafter the finished rod 30 leaves the belt, which returns via driving roller 10 and the tensioning rollers 11. The mixture may comprise sorbent granules together with finely powdered thermoplastic resin, or sorbent granules coated with resin, or both, prepared as previously described, the preferred materials being activated carbon of 60 a granule size of from 12 to 50 mesh U.S. Standard and polyethylene of melt index 65 greater than 5 and particle size 50 microns

or less.

The belt 6 is preferably of woven nylon, coated with a baked-on silicone emulsion and sufficiently porous to permit the passage of air and steam therethrough. The coating 70 improves the water resistance of the belt and inhibits adhesion of the belt to the particulate material. When mixtures including finely powder particles are employed, the powder 75 tends to adhere to the surface of the larger sorbent granules, even on initial mixing, so that the pores of the belt need be smaller than only these larger granules.

As the belt 6 passes under the hopper 2 to the suction station 22 it is supported on 80 a former 46 which shapes it to a semi-cylindrical configuration, whereby spilling of the mixture is prevented. The mixture is fed onto the belt by way of an inclined vibrating shelf or chute, the rate of feed being controlled by adjusting the rate of vibration. 85

In the suction station 22 the belt is unsupported at its under-side, as shown in Fig. 2, or is supported only on a semi-cylindrical 90 grid, and a partial vacuum is maintained under the belt as it passes therethrough to remove any material clinging to its under-side. The partial vacuum created also tends to prevent steam, escaping from the steam treating station 24, from disturbing the mixture on the belt. 95

As the belt passes from the suction station 22 to the steam treating station 26 it is closed to form a cylinder under the action of the formers 61, 61', which as shown in 100 Fig. 3 constitute a cylindrical passageway.

Leading into the passageway 63 are a plurality of inlet bores 64 (Fig. 4) communicating with a supply channel 66. Steam is supplied to the channel 66 via an inlet 68 105 and thence through the bores 64 and through the porous belt passing through the passageway. The bonding agent in the mixture retained in the belt is softened on contact with the steam to bond the sorbent granules together as previously described. If the belt 6 is not completely full as it enters the station 24, the steam also serves to disperse the particles so that the mixture fills the tube completely, leading to the formation of a rod of 115 relatively high porosity and low density. The porosity, density and pressure drop of the finished rod may thus be controlled by adjusting the rate of feed of mixture from the hopper 4 relative to the speed of the belt. 120 The belt, still in the form of a closed cylinder, passes from the station 24 to a cooling station 26 (Fig. 5) comprising a housing 70 having a cylindrical passageway 72 into which lead a plurality of bores 74. Air is supplied through an inlet 78 and via a channel 76 125 into the bores, thereafter passing through the belt to cool the filter rod therein. As shown in Fig. 5 the air is fed countercurrent to the moving belt. Apart from the cooling effect 130

of the air, condensation within the rod is eliminated in this step and its porosity is maintained. Cooling causes shrinking of the rod which is thus easily separated from the belt as the latter is flattened out for return to the hopper 4. The filter rod 30 may be passed continuously as it is formed to a conventional cigarette filter machine bed 32 in which it is wrapped in a substantially impervious wrapper, e.g. of paper and severed into multiple length filter units by means of the cutter 34. These may then be fed into a cigarette machine where they are sub-divided into individual filters and attached to cigarettes.

The best results are achieved if the distance through which the belt travels in the steam chamber before encountering the steam injection ports is greater than the length of the segments into which the rod is ultimately cut.

The method described above is mechanically simple and can be operated continuously at high speed in conjunction with conventional cigarette-making machines, the filtration properties of the product being variable at will and readily and accurately controllable during production.

The filters produced by the method of the present invention are more efficient than smoke filters that have been available heretofore as regards the retention of vapours and solids. They may be cut cleanly and efficiently by the apparatus conventionally employed for segmenting filter rods to form individual cigarette filters, and indeed cause considerably less blunting of and damage to the cutters than do carbon-containing filamentary tow filters. The filters may be used alone or in conjunction with, for example, a conventional tow filter. In such a composite cigarette filter the bonded particulate section may be disposed between the tow element and the tobacco of the cigarette and preferably constitutes at least half, e.g. two-thirds or more, of the total filter.

The invention will now be further described with reference to the following specific Example.

The term "pressure drop" used herein refers to a pressure drop measurement between the ends of a filter rod having a substantially impervious wrapper over its cylindrical surface; air is passed through the wrapped filter at a rate of 17.5 ccs/sec, and the pressure difference between the inlet and outlet ends is measured in cms water gauge.

EXAMPLE

A filter rod was formed by the method described in detail above using activated carbon and polyethylene having a melt index of about 20 as determined by the test specified in ASTM D 1238-57T. The carbon granules were such as to pass a 20 but not a 50 mesh screen and the resin powder was of a particle

size less than 50 microns.

The conditions employed were as follows:—

belt speed	— 30 m/minute.
suction pressure	— minus 2.5 cms of water
steam temperature	— 127° C to 149° C.
steam flow rate	— 4.5 Kg per hour.
air flow rate	— 283 litres per minute.

The mixture was fed on to the belt at such a rate as to yield a rod showing a pressure drop of 2.5 cms of water per 10 mms length of rod, the finished rod having a diameter of 8 mms.

In Fig. 6 of the accompanying drawings, line A is a plot of number of puffs against the concentration of objectionable constituents in the gas phase of the main stream smoke of a cigarette fitted with a filter produced as in the above Example. Line B is a corresponding plot obtained in the case of a cigarette with a conventional filter comprising loose carbon retained between plugs of filamentary tow, and line C that obtained in the case of a similar cigarette with no filter.

Filter rods were formed with similar success by the procedure of the Example employing various mixtures of sorbents, bonding agents and fillers and additives as set out in the preceding description.

The invention thus provides a method of forming a smoke filter in which sorbent granules constitute an essential and predominant part of the structure. In contrast, previous methods have allowed the use of granular sorbents such as activated carbon only as additives, for example in continuous tow or paper type filters, the increase in filtration efficiency obtainable being limited by the limited amount of such additive that could be satisfactorily retained in the filter.

WHAT WE CLAIM IS:—

1. A method of forming a porous body suitable for use as a tobacco smoke filter comprising feeding a mixture of sorbent granules and a thermoplastic binding agent therefor on to a flexible belt, shaping the belt to collect the mixture into a body of the required configuration, heating the shaped mixture to form it into a coherent porous body, and thereafter separating the body from the belt.

2. A method according to claim 1 wherein the flexible belt is of porous material, the belt being shaped into a tube to collect the mixture into a rod and steam being thereafter passed through the pores of the tube into the mixture to form the mixture to a coherent porous filter rod.

3. A method according to claim 2 wherein the mixture on the belt is first passed through a suction station whereat a partial vacuum is applied to the underside of the belt.

4. A method according to claims 2 or 3

- including the additional step of passing a coolant gas through the pores of the belt to cool the filter rod before it is separated from the belt.
- 5 5. A method according to any of claims 1 to 4 wherein the mixture comprises sorbent granules coated with the bonding agent.
6. A method according to any of claims 1 to 5 wherein the mixture comprises granules of sorbent material and particles of the bonding agent.
- 10 7. A method according to claim 6 wherein the mixture is subjected to a gentle pre-heating step.
- 15 8. A method according to claim 6 or 7 wherein at least 80% of the sorbent material has a particle size of up to 200 times that of the bonding agent.
9. A method according to claim 8 wherein at least 80% of the sorbent material has a particle size of from 9 to 60 times that of the bonding agent.
- 20 10. A method according to any of claims 1 to 9 wherein the sorbent material has a particle size of from 10 to 200 mesh U.S. standard.
- 25 11. A method according to claim 10 wherein the sorbent material has a particle size greater than 100 mesh.
- 30 12. A method according to any of claims 1 to 11 wherein the mixture additionally includes one or more fillers and/or additives.
13. A method according to any of claims 1 to 12 wherein the sorbent material comprises granules of activated carbon.
- 35 14. A method according to claim 13 wherein the activated carbon is derived from coal.
15. A method according to any of claims 1 to 14 wherein the bonding agent is a polyolefin.
- 40 16. A method according to claim 15 wherein the polyolefin has a melt index of 5 or more.
17. A method according to any of claims 13 to 16 wherein the mixture comprises granules of activated carbon with a bonding agent of approximately the same apparent density.
18. A method according to any of claims 1 to 17 wherein the mixture includes granular tobacco.
19. A method according to any of claims 1 to 18 wherein the mixture comprises from 50% to 95% of sorbent granules and from 5 to 50% of bonding agent.
- 55 20. A method according to claim 19 wherein the mixture comprises not more than 40% of bonding agent and at least 60% of sorbent granules.
- 60 21. A method according to claim 19 or 20 wherein the mixture includes from 6½% to 30% of bonding agent.
22. A method according to any of claims 1 to 17 wherein the mixture includes from 85% to 93½% of sorbent granules.
- 65 23. A method of forming a tobacco smoke filter substantially as hereinbefore described with reference to the accompanying drawings.
- 70 24. A tobacco smoke filter produced by the method of any one of claims 1 to 23.
25. A tipped cigarette including a filter according to claim 24.

REDDIE & GROSE,
Agents for the Applicants.





